SELECTED APPLICATIONS OF INTERVAL AND FUZZY ANALYSIS IN BIOMECHANICS

A. John and P. Orantek
Department for Strength of Materials and Computational Mechanics,
Silesian University of Technology, Poland

1. Introduction

Bioengineering concerns many significant problems applied to the human body. The pelvic bone is one of the most important supporting elements in human pelvic joint but it is exposed to the injuries. Very often before and after surgical intervention the expertises about the stress, strain and displacement distributions in the pelvic bone are needed. For the safety of the patient there are only two possibilities available to derive mentioned values: model testing and numerical calculations. The numerical model should be prepared before numerical calculations [1,2,3]. Numerical calculations require the characteristics of the material properties and the material parameters from the beginning. Usually the literature is the source of the material parameters, but sometimes this data is not suitable for the implementation. This is a reason for the experimental investigations to identify these parameters [4,5,6]. It is well known that material properties of the living body depend on many factors: age, health, gender, environment and many others changing in time. As we are interested in results of analysis not only for a one patient but for a group of patients, we should assume an interval value of material parameters. In this paper the test of the interval and fuzzy analysis of the pelvic bone is presented. The interval and fuzzy analysis concerns material properties. The finite elements method is applied [7,8,9].

2. The interval and fuzzy analysis of the human pelvic bone

The human pelvic bone is restrained in pubic symphysis and on contact surface with sacral bone. It is loaded with force F acting in artificial acetabulum. Two cases of the linear elastic analysis were carried out. In the first case the material parameters are not position-depended. In the second case the selected material parameters depend on the position in the bone.

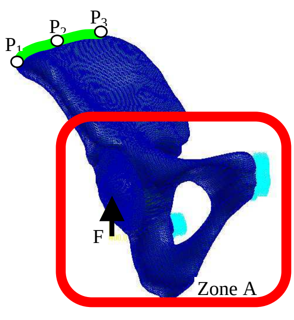

Fig. 1. The model of the human pelvic bone

For both cases the interval and fuzzy (two alpha-cuts-trapezoid) approaches are applied. It was assumed that for the interval analysis, the Young moduli of trabecular bone (in both cases) was constant and equal [1.8E8; 2.2E8]. The Young moduli of the cortical bone (in the first case) was modelled as the interval [1.8E10; 2.2E10]. In the second case the Young moduli of the cortical bone was equal to the interval [1.8E10; 2.2E10] in zone A (Fig.1) and was equal to [0.9E10; 1.1E10] in the bound B (between P1 and P3). In space between zone A and the bound B, the Young moduli was generated with the linear weight function.

In the fuzzy analysis case, the Young moduli of the trabecular bone (in both cases) was constant and equal to the fuzzy number (see Table.1). First the Young moduli of the cortical bone was modelled as the fuzzy number (see Table.1). The space between zone A and the bound B was determined with linear function.

The rest of parameter were assumed as the determine numbers.

Table 1. The fuzzy material parameters and displacements of point P_1

E1 [e+10] [Pa] cortical	E2 [e+8] [Pa] trabecular	Px_1 [e-7] [mm]	Py_1 [e-7] [mm]	Pz_1 [e-7] [mm]
1.8 2.2	2.66 3.24	2.66 3.24	2.70 3.27	-3.34 -2.74
1.6 2.4	2.44 3.64	2.44 3.64	2.47 3.68	-3.76 -2.51

3. Conclusions

Arithmetic analysis enables evaluation of the selected characteristics (strain, stress and displacements) not only for a discrete deterministic material parameters, but for assumed interval. It satisfies reality more precisely. Obtained results can be useful to plan and assess quality of the surgical intervention. The surgeons can observe which states are dangerous for the patients.

4. Acknowledgement

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5. References

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